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ABSTRACT

Understandings and cooperation must be improved between researchers in pure science and applied science, and in this case, industrial arts. Technology has crept into science but is seldom an organized part of the science curriculum. Few science teachers have contact with engineers or technologists, while industrial arts teachers typically have weak science backgrounds--facts that leave the door wide open for establishing extensive relationships between industrial arts (technology) and science. The two areas can contribute to each other for their mutual benefit. The basis for productive relationships at the secondary and teacher education levels does exist, but only if both parties can communicate what they have to offer. One of the first steps to logical and effective communication is settling on some standard definitions to improve the possibilities for greater understanding. A salient distinguishing characteristic between science and technology is that science observes nature in order to derive principles, laws, and generalizations, while technology practices in order to test or refine theories of efficient action. Technology/industrial arts educators are often confused and duplicate existing instruction in academic subjects deemphasizing laboratory activities. Industrial arts teachers must be able to teach industrial technology as a laboratory subject. (YLB)

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SCIENCE & TECHNOLOGY:
A NEW ALLIANCE

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SCIENCE AND TECHNOLOGY: A NEW ALLIANCE

Despite the title, mine is not a new topic. If one wants confirmation, review Snow's 1959 work, The Two Cultures and the Technological Revolution. In it, he essentially advocated a closer relationship between the academicians and technologists, for the good of society. Most briefly, his concern was that ". . .the whole of western society is increasingly being split into two polar groups" (p. 4). Actually, he called his two "cultures" the "academic" and the "scientific," a strange dichtomy since he admitted to there being a further division within the scientific group, the pure and applied subgroups. He chose to make little of the fact that some of his scientists in fact belonged more typically to the literary or academic group. With regard to this problem, he said, "It is permissible to lump pure and applied scientists into the same scientific culture, but the gaps are wide" (p. 33). A little further on he elaborates by saying:

> Pure scientists have by and large been dim-witted about engineers and applied science. They couldn't get interested. They wouldn't recognise that many of the problems were as intellectually exacting as pure problems, and that many of the solutions were as satisfying and beautiful. Their instinct--perhaps sharpened in this country by the passion to find a new snobbism wherever possible, and to invent one if it doesn't exist--was to take it for granted that applied science was an occupation for second-rate minds. . .We prided ourselves that the science we were doing could not, in any conceivable circumstances, have any practical use. The more firmly one could make that claim, the more superior one felt. (pp. 33-34)

Lord Snow may have been more precise if he had retitled his work The Two Cultures and the (~~Scientific~~) Technological Revolution and not

tried to "lump" pure and applied scientists. Using the dichotomy of academicians and technologists would have provided more discrete groupings, since the "pure" scientists are more nearly like the former than the latter. Despite some semantical differences, the fundamental thought is the same, there is the need to improve understandings and cooperation between the pure and applied scientists, as well as with them to the broader academic community, for the improvement of education and for the good of society. And while the integration of all subject matter is a vital concern, progress can perhaps best be made a step at a time. Further, if we cannot successfully develop and extend relationships with the science teachers, where more obvious opportunities are evident, there is less hope of solving the larger problem. Thus, this presentation is delimited to science-industrial arts relationships.

Industrial arts has been torn by enough internal dissention to perhaps cause many to question why one should even look for further linkages and, in the process, invite any further dissention and criticism which could result. An alternate position, one held here, is that rational dissention and criticism are desirable and may be expected to produce better results than might come from trying to follow the path of least resistance. Clearly, "science and technology" are the buzz words of the moment, and maybe the time is ripe to realize the aspirations which Snow sought a quarter of a century ago.

My personal conviction is that the growing popularity of the phrase "science and technology" is attributable to the fact that more

and more people are growing uncomfortable with the prospects of studies in science alone preparing people for life in the balance of this century and the next. Maybe the combined terms "science and technology" just sound timely, like "high technology," and further efforts to understand their meaning only destroy their charm and the ability to let them mean whatever individuals wish for them to mean.* The thesis in this presentation, however, is that words or terms loosely used serve little scholarly purpose. Thus an effort is made to logically define them, to see what use more precise meanings might serve in fostering interdisciplinary studies, and to see how more exact communication could avoid confusion and wasteful duplication of effort and work improvement in the rigor and uniqueness of industrial arts programs.

On the matter of the nature of the relationship between science and technology, DeVore's generalizations are not difficult to summarize or to accept. They are generally supported in the literature. He states, "Most writers conclude there are differences between technology and science" (p. 237). He agrees with those who have concluded that sometimes science leads technology and sometimes the roles are reversed, that there is no convincing evidence that linkages between the two exist in any regular and predictable pattern, and that the oft-assumed truism that scientists create new knowledge which technologists put into practice is largely incorrect. Most who thoroughly study the record probably will come to similar conclusions.

* For more on this thought, read Talking Tech (see Bibliography).

Scientists on our campus most often do not know the engineers, and vice versa. Each group has its own scholarly community, goals, values, and rewards, as well as their respective and discrete on-campus and off-campus clienteles. And, as Kranzberg concludes, "new technology grows out of old technology, not out of science," and "scientists concern themselves chiefly with the problem posed by science, not by technology" (p. 27).

To this point, little has been presented that would encourage one to believe that science-technology relationships exist or that closer relationships can in fact be developed. To confirm that the potential relationships do exist people only need to visit their area "science fair" or the more recent "olympics of the mind" contest. Only the former events are national in scope at this time, and both have been thus far dominated by science teachers. Even the dilettante could go to a science fair and, with a few criteria, make up a listing of student projects which are more science-like and which are more technology-like. And one would find a sizable proportion of the projects in each category. Perhaps in recognition of this fact science fairs are becoming science and engineering fairs.

The presumption here is that the primary criterion for judging what is a science project would be that it illustrates some natural principal or phenomenon or law, while the other group of projects would show solutions to practical problems. For example, the grand prize winner of this year's local science fair in our area was an operational spot welder. Our area olympics of the mind winner

developed a three-wheeled vehicle, driven by rubber bands cut from inner tubes, that could carry an individual over a given course. Thus, much technology has crept into science, but technology is seldom an organized part of the science curriculum and seldom do the science laboratories provide the tools, equipment, and materials to support adequate or even minimal instruction in technology. Further, few science teachers have had even the remotest contact with engineers or technologists, just as industrial arts teachers typically have weak backgrounds in science. These facts leave the door wide open for establishing extensive relationships between industrial arts (technology) and science. Each area has something unique to contribute to the other, to their mutual benefit.

In The Ohio State University Laboratory School I have observed a complete and effective working relationship between industrial arts and science teachers. The design and production of science-related hardware was done by students in the industrial arts laboratory, overseen by a science and industrial arts team. By the same token, projects initiated by students in the industrial arts laboratories which raised questions best answered by science saw students carrying those questions to the science classrooms and laboratories. There they sought answers to their science questions, again under the joint guidance of the science and industrial arts teachers. Both programs prospered as a result of this relationship. Similar relationships can and perhaps ought to be promoted in every school.

At the teacher education level similar relationships can be developed, in this case also involving engineering or industrial technology, if the particular institution is fortunate enough to have these programs on campus. Again, in our situation, we have found evidence of how natural and productive these relationships can be. We have promoted group studies courses involving students from more than one department. In one instance, the problem was the fabrication of an inertial drive automobile with the initial interest coming from a master's thesis in mechanical engineering which had as its problem the theoretical design of the flywheel. While science and engineering students have an edge on industrial arts majors in the theoretical design of such an object, industrial arts students have an immediately evident advantage and contribution to make when it comes time to produce the object. Similarly, another interdepartmental group studies project related to the development of an airmobile. When such a project is undertaken it is clearly evident what the respective strengths and weaknesses of the different students are and how the joint studies produce benefits which are difficult to impossible to achieve if each group goes off to their respective, isolated departments.

A major potential problem exists in attempting to promote a joint venture. In order for progress to be made, the cooperating parties have to be able to communicate with each other, and each has to know what they are about as well as what the other person is trying to do. Only then can both parties identify their respective strengths and weaknesses and work out and communicate a plan of mutually beneficial

team action. Without this, the teachers and students can only become confused and be subjected to wasteful overlap and duplication of effort.

One of the first things that people must do in order to have a logical discussion of science and technology is to decide what the respective terms mean. Only babble can result until this fundamental problem is addressed. Evidence abounds as to the nature of this problem. For example, Carl Sagan has said:

> We have a society which is built on science and technology and which uses science in every one of the interstices of natural life, in which the public, the executive, the legislative, and the judiciary have very little understanding of what science is about. That is a clear disaster signal. It has to be suicidal. (Rheingold & Levine, p. 7)

Notice how "technology" is left hanging in the above quote. It is alleged that society is built on science and technology, but it is inferred that the only lack of public understanding is with regard to science. Since every American who has gone to school has studied science but few Americans have formally studied technology, there is reason to suspect that the greater public ignorance is with regard to technology.

Glenn Seaborg has said:

> People must understand that science is inherently neither a potential for good or for evil. It is a potential to be harnessed by man to do his bidding. And man will determine its direction and its effect. Man, therefore, must understand science if he is to harness it, to live with it, to grow with it. (Rheingold & Levine, p. 9)

In this instance, a noted scientist seems to be speaking about science but probably is talking about technology. Few scientists will agree that "Man will determine its (science's) direction and its (science's) effects." For example, does man determine whether the sun tomorrow morning will arise in the east, and how will man change the effects if it doesn't? Science is a study of what is. Technology is a study of what might be and of how to bring it about.

Even the authors of the humorous and satirical work Talking Tech have problems similar to those above. For example they state:

> Science has been pulling us along into uncharted territories at a dizzily accelerating rate. And something has been happening to our minds along the way: Our attitudes toward science and technology have been changing. It started to happen somewhere between the Salk vaccine and the Love Canal, sometime after Atoms for Peace but before the monster from Three Mile Island. One morning we awoke to the thought that perhaps scientific progress wasn't our most important product after all. (Rheingold & Levine, p. 10)

Do you think they really mean "Science has been pulling us all along into uncharted territory at a dizzily accelerating rate?" I doubt that science pulls anywhere. Science informs and explains. And why does the lead sentence only mention "science," when in the following sentence up pops "technology."

If noted individuals and authors can be imprecise, one could argue that teachers are at liberty to behave similarly. At least one difference is that teachers are being paid to inform and not to confuse. Another is that students are not at liberty to ignore the ones to which they are assigned and to seek out less confusing and more logical ones.

In looking for more precise communication we do need to settle on some definitions and, preferably, they ought to be more or less standard ones thereby improving the possibilities for greater understanding. Rheingold and Levine admit to the problem by saying:

> The phrase 'science and technology' encompasses so many subcategories that it must be understood as a very broad classification, a kind of galactic cluster of related concepts, many of which have planetary subsystems of their own. When you hear somebody discussing science or technology, he could be talking about a scientific pretender (common sense, nonscience, prescience or pseudoscience), a scientific cognate (research, development, engineering, or technology), or a scientific qualifier (applied, basic, experimental, or theoretical). . .. (pp. 17-18)

Talking Tech offers some flippant definitions. For example, research is defined as "the Holy Grail," and engineering is defined as "science's poor cousin." However, even that work has no trite definition of technology. Rather, it defines technology as ". . . the production or transformation of material objects and the creation of procedural systems" (p. 19). Industrial arts teachers would do well to think long and hard about that definition, as it seems to be in fact talking about industrial technology, as industrial arts always has, except in some very recent instances.

Certainly the simplest of basic definitions of science and technology are neither complicated nor unfriendly to the idea that a natural relationship between them exists. As a school subject, science offers a systematic study of knowledge about nature, while technology is a systematic study of how people alter nature to make it of more

use or value. A fact of technology, as well as of science, is that each has many subelements.

Industrial arts teachers would certainly recognize that there are social sciences and natural sciences, for example, and that even each of those subcategories require extensive, specialized teacher preparation. Thus, industrial arts teachers should easily recognize and understand that there are major subdivisions of knowledge of doing (technology). Common school examples would be business, health, sports, and art technologies. And each of these requires extensive, specialized teacher preparation. Only the naive would expect a science teacher to teach, at the secondary school level, all of science. Similarly, for a teacher to claim to be qualified to teach all of technology would show extreme naivete.

One salient distinguishing characteristic exists between science and technology. Science observes nature in order to derive principles, laws, and generalizations. Technology practices in order to test or refine theories of efficient action, which can only be derived from practice. Knowledge (ology) of practice (techn) is technology. Thus, in science one can study wave phenomena, but for technology to be something different, it must demand something else. It requires, for example, that one harness wave energy for a useful purpose or practice playing an instrument or sound one's vocal chords until a predictable result (technology) will occur, and one may even practice technology until the predictable result is habitual, in which case we call it a skill.

People who claim to be scientists can be satisfied to explain. People who claim to be technologists also must be able to do. Of course simply doing, though essential, is not enough. It must be that clever blend of thoughtful doing which industrial arts has long sought but seldom found. Social critics of technology (Jane Fonda, for example) are not technologists. Neither are any others who only discuss technology or study it in the abstract. Such studies are of descriptive knowledge, not of technology. This fact seems lost on many technology educators. One does not become any part of a true technologist by only talking. Practice is an essential but not sufficient characteristic of technology. That is, with the practice must go the theory of that practice, otherwise it is mere doodling. And theory without practice is mere intellectual exercise.

The proud heritage of industrial arts countenances all of this. Note carefully what Woodward adopted for the motto of the first American manual training (yes, it could have been called "technological") high school:

> Hail to the skillful, cunning hand!
> Hail to the cultured mind!
> Contending for the world's command,
> Here let them be combined.

Note well what Professor Kuno Franke, of Harvard University, said after observing Woodward's students at work:

> Since the days of Rousseau, the effort to educate the rising generation in a more harmonious way than is possible in a school which aims only at the acquisition of mere scholarship has never been abandoned. . .

> . . .all these manifestations are still only symptoms of the one fundamental idea, that education must be directed, not to know, but to be able to do, not to words, but to deeds. . .
>
> He who has learned to use his hands systematically has now a clearer conception between thought and fact, between theory and practice; and this clearer knowledge will enable him to form more correct judgements in those two great spheres of observation, the real and the ideal, than is possible for one whose power of observation has been cultivated exclusively in ideal things. (Woodward, pp. 170-171)

Industrial technology is but a subsystem of technology as are agricultural, business, medical, and other technologies. Industrial technology is not and will not decrease in its significance to society. So long as society uses other than natural objects, it will be dependent upon industrial technology. So long as people wish to use computers, housing, transportation devices, communications devices, etc., they will be dependent upon and their culture will be affected by industry. The numbers who work in industry, either in actual numbers or as a proportion of the labor force, may decline. The significance of the role of industry and its unique knowledge of practice (technology) will not decline. It will increase!

The recent rash of would be technology educators (Where have they been for most of the last forty years while Warner's almost lone voice pleaded for conversion to industrial arts courses in Communications, Construction, Manufacturing, Power, and Transportation?) would be well advised to more seriously study their positions. A prime example of where we now are may be seen in a recent issue of Man/Society/Technology.

Some technology educators offer these terminal performance results after students have studied what is alleged to be technology:

> After reading this unit, you will be able to:
> * Identify three ways our lives have been changed by developments in transportation.
> * Describe the importance of transportation in today's society.
> * Discuss how transportation has changed social relationships.
> * Describe three government agencies that regulate transportation. (M/S/T, p. 17)

Are any of these learnings not already in the academic program? If you believe they are not, please do a cursory content analysis of any current secondary school social studies text. Is the thesis that this needs to be repeated? What, then, is the rationale for having industrial arts laboratories, equipment and materials? Or are these not needed?

Is there anything listed which one would only know through practice? Where are the key words such as design, inspect, troubleshoot, adjust, separate, combine, form, etc.? Are industrial arts laboratories to become additional classrooms, filled with endless practice with words?

The suggested quiz items further confirm the redundancy.

> Now that you have worked through this, try a SELF-QUIZ. On your own sheet of paper, write the answers to these questions.
> 1. What was the first major breakthrough for humans in improving their means of transportation? (history)*
> 2. How has an increasingly interdependent world affected the products we use in our daily lives? (economic geography)*
> 3. What changes have automobiles made in our social relationships? (social studies)*
> 4. What three federal agencies act to regulate transportation in the U.S.? (government)* (M/S/T, p. 20)

* Added by this author.

Again, do we need certified industrial arts teachers and laboratories to teach this new breed of technology education? Countless examples of two prominent tendencies of the new technology education advocates are clearly discernable. On the one hand, they talk of a new subject matter and then offer the old breadboard and footscraper activities. On the other hand they talk of a new subject matter and teach what already is covered elsewhere in the school. Such confusion among the teachers (perhaps more accurately, among the teacher educators) can only hopelessly confuse students. And it can form little basis for making science-technology relationships bloom. "Know thyself" is still a wonderful place to start in getting to know others.

Of course, the issue is not whether industrial arts needs to be changed. It is, rather, whether technology or industrial technology is to be the subject matter of industrial arts. All school subjects rightfully may claim some technology as rightful content in their respective areas. And industrial technology is a comprehensive and pervasive element of the human heritage. It will challenge the total creative and professional abilities of industrial arts teachers to teach it, as a laboratory subject, without looking to other equally complex elements of technology, for which they have neither the experience nor the laboratories.

In summary, science and technology are current buzzwords. There is much confusion as to what people mean when they use the phrase, and much more precise meanings must be used if effective relationships between science and technology are to be achieved. But the basis for productive relationships do exist, if both parties can communicate what they have to offer.

Would-be technology educators are especially confused. By their words and actions and recent publications they too often demonstrate that what they are advocating has little to do with the industrial arts heritage, which remains sound. It also often seriously duplicates existing instruction in academic subjects and deemphasizes laboratory activities, which are essential to a true study of technology.

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